SD11
A571
#377

USDA United States Department of Agriculture

Forest Service

North Central Research Station

Research Note NC-377
2001

Indiana's Forest Resources in 1999

Patrick D. Miles

ROCKY MOUNTAIN RESEARCH STATION LIBRARY
FORT COLLINS CENTER
240 W PROSPECT RD
FORT COLLINS, CO 80526-2098

ABSTRACT.—The North Central Research Station's Forest Inventory and Analysis Program began fieldwork for the fifth forest inventory of Indiana in 1999. This inventory initiates a new annual inventory system. This Research Note contains estimates of Indiana's forest resources prepared from data gathered during the first year of the inventory.

KEY WORDS: Annual inventory, forest land, forest type, growing-stock volume, Indiana.

BACKGROUND

The North Central Research Station's Forest Inventory and Analysis Program (NCFIA) began fieldwork for the fifth forest inventory of Indiana in 1999, in cooperation with the Indiana Department of Natural Resources. This inventory initiates a new annual inventory system. Under this new system, one-fifth of the field plots in the State are measured each year. As a result, the current inventory of Indiana's forest resources will not be fully implemented until 2004. However, because each year's sample is a systematic sample of the State's forest and because timely information is needed about Indiana's forest resources, estimates of Indiana's forest resources have been prepared from data gathered during the first year of the inventory. **Due to the limited number of field plots measured, future estimates using data in this report are subject to change when ensuing annual inventories are completed and data compiled.** The results presented are estimates based on sampling techniques. As additional annual inventories are completed, the precision of the estimates will increase and additional data will be released.

Reports of previous inventories of Indiana are dated 1950, 1967, 1986, and 1998. Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for the comparisons to be valid, the procedures used in the two inventories must be similar. As a result of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred since the last Indiana inventory in 1998 (Schmidt *et al.* 2000). Some of these changes make it inappropriate to directly compare portions of the 1999 data with those published for 1998. When comparisons are made or estimates presented from past inventories in this report, data from previous inventories are recomputed using current methods to ensure that comparisons are valid.

RESULTS

Before European settlement, forests covered an estimated 80 percent of the State. Except for Benton County and parts of other counties in the northwestern section of the State, Indiana was covered with one of the finest stands of hardwoods in America (Brundage 1955). Between initial European settlement and the first inventory of Indiana's forests in 1950, the area of forest land declined 18 percent of the State's land area or about 4.14 million acres. The second inventory in 1967 of Indiana's forest lands estimated that about 3.96 million acres were forested. In 1986 the estimated area of forest land increased to 4.44 million acres. Twelve years later, in 1998, the estimated area of forest land was 4.50 million acres. The following year, in 1999, under the

PATRICK D. MILES is a Research Forester with the North Central Research Station, St. Paul, MN.

annual inventory system, the estimated area of forest land declined to 4.23 million acres. Indepth analysis of the 1998 and 1999 inventories indicates that the decrease in estimated forest land area may be a result of the high sampling error associated with the 1999 estimates rather than a loss of forest land between the two inventories (Hansen *et al.*, in press).

The increase in forest land over the last 30 years is due in large part to changing agricultural practices. Marginal croplands have been allowed to convert back to forest land. Domestic livestock grazing methods have changed as operations have switched from open grazing to confinement systems. These changes, combined with effective wildfire control, have allowed forests to become reestablished.

Timberland has followed the same trend in Indiana. Timberland is the subset of forest land that is capable of growing trees at a minimum level (20 cubic feet per acre per year) and that is not restricted from harvesting. The estimated area of timberland increased by nearly 14 percent between the 1967 and 1998 inventories (fig. 1). The nearly 6-percent decline from 1998 to 1999 may be due to sampling error.

Most of the land area of Indiana is gently rolling, tillable, and suited to growing cultivated crops (Hutchison 1956). However, about one-sixth of the State is unglaciated. This unglaciated region in the southern part of the State has more rugged terrain and less fertile, more erodible soils than found in the north. Some of the greatest concentrations of forest land are found in southern Indiana.

Forests in the northern glaciated region of the State now occur mainly as farm woods, occupying poorly drained soils, stony moraines, steep slopes, and stream margins. The forests in this region are more dispersed and are found, on average, in smaller tracts.

Indiana is well known for its oak-hickory and maple-beech forests. Every inventory conducted in the State has shown them to be the dominant forest types. The 1999 inventory estimates that 84 percent of the timberland in Indiana is in these two types (fig. 2).

The decline in the estimate of timberland area between 1998 and 1999 is reflected in the estimated decline in growing-stock volume over the same period. It is not clear whether this decline is real or the result of sampling error. Fortunately, under the annual inventory system, additional data will soon be available to improve the accuracy of the volume estimates.

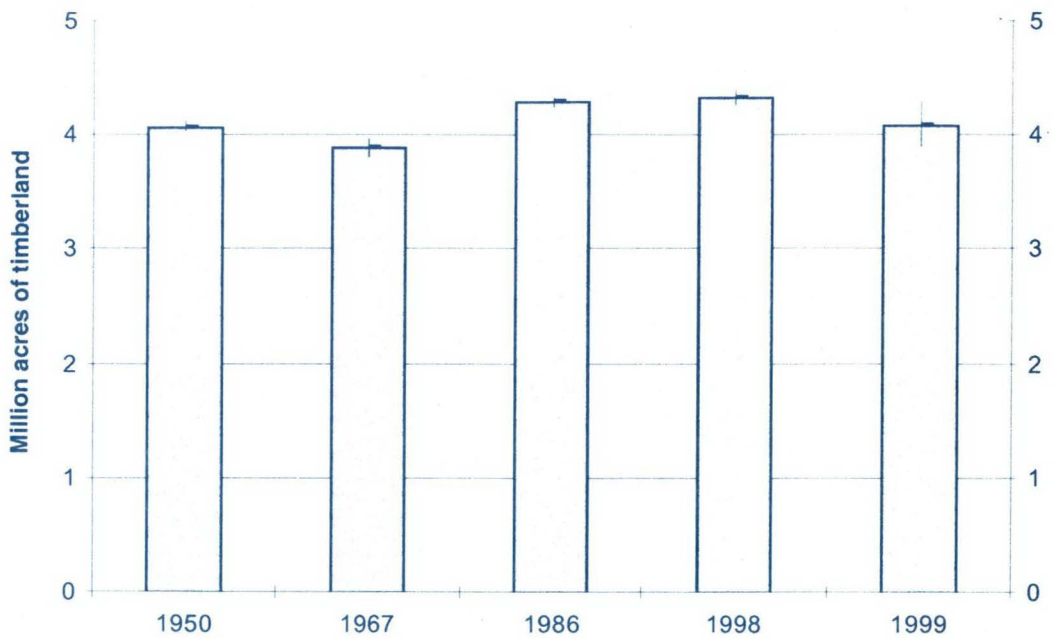

Figure 1.—*Area of timberland in Indiana by inventory year (Note: sampling errors associated with each inventory are represented by the vertical lines at the top of each bar).*

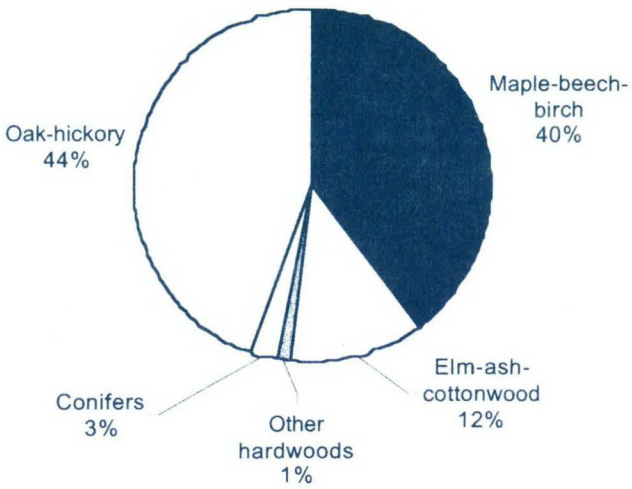

Figure 2.—*Area of timberland in Indiana by forest type, 1999.*

Growing-stock volume is the amount of solid wood on timberland in trees 5 inches d.b.h. and over, from 1 foot above ground to a minimum 4-inch top diameter with deductions made for poor form or defect. As trees increase in diameter and as the timberlands increase their stocking rate, the volume of wood increases correspondingly. Growing-stock volume estimates have increased between every inventory of Indiana's timberlands except for the 1999 inventory (fig. 3). The increase in growing-stock volume is a reflection of increases in stocking, tree size, and timberland area. Another factor in the increase of growing-stock volume between inventories is the conversion of some non-growing-stock trees (primarily either having rough form or having rotten portions of the live tree) to growing stock because of improved quality.

In 1999, the majority of the growing-stock volume in Indiana was in the oak-hickory species groups (39 percent), followed by the maple species groups (14 percent), and the yellow-poplar group (13 percent). Hardwoods dominate in Indiana, representing more than 97 percent of the total growing-stock volume.

In summary, there are insufficient data to clearly indicate how Indiana's forest resources have changed since the 1998 inventory. As additional data become available under the annual inventory system, a clearer picture of the direction of Indiana's forests will emerge. Until then, the 1998 inventory remains the best source of data on Indiana's forest resources.

INVENTORY METHODS

Changes Between Inventories

Since the 1998 inventory of Indiana, several changes have been made in NCFIA inventory methods to improve the quality of the inventory as well as meet increasing demands for timely forest resource information. The most significant difference between inventories is the change from periodic inventories to annual inventories. Historically, NCFIA inventoried each State every 15 years, on average. However,

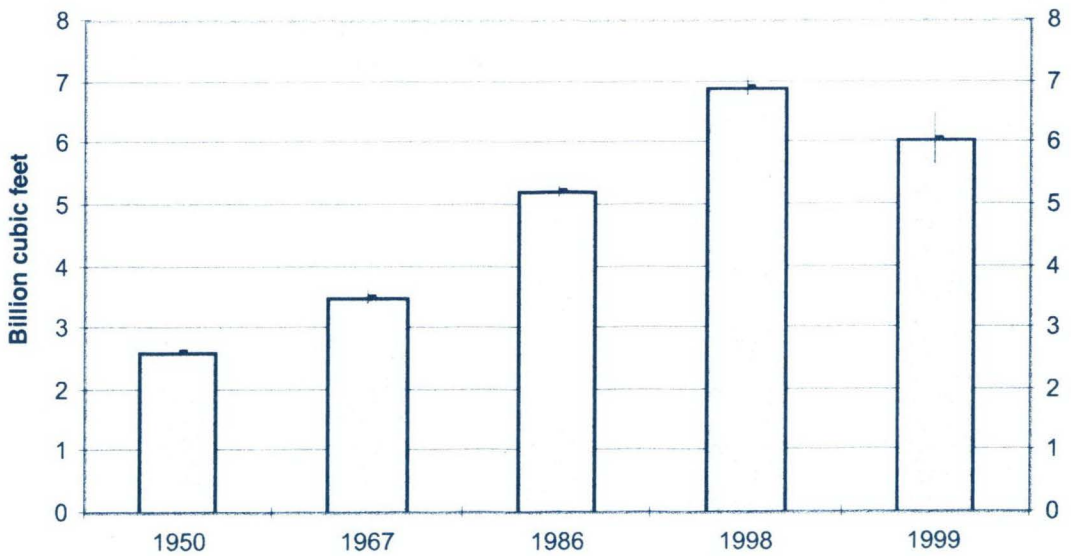

Figure 3.—*Growing-stock volume in Indiana by inventory year (Note: sampling errors associated with each inventory are represented by the vertical lines at the top of each bar).*

the need for timely and consistent data across large geographical regions, combined with national legislative mandates, resulted in NCFIA's implementation of an annual inventory system. Indiana was one of the first States in the North Central region, and one of the first States in the Nation, to be inventoried with this new system, beginning with the 1999 inventory.

With an annual inventory system, about one-fifth of all field plots are measured in any one year. After 5 years, an entire inventory cycle will be completed. After the first 5 years, NCFIA will report and analyze results as a moving 5-year average. For example, NCFIA will be able to generate a report based on inventory results for 1999 through 2004 or for 2001 through 2006. While there are great advantages for an annual inventory, one difficulty is reporting on results in the first 4 years. With the 1999 inventory, only 20 percent of all field plots have been measured. Sampling error estimates for the 1999 inventory results are 4.56 percent for timberland area and 6.77 percent for growing-stock volume, much higher than the sampling errors for the last periodic inventory completed in 1998 (1.59 percent for timberland area and 2.18 percent for growing-stock volume). Thus, caution should be used when drawing conclusions based on this limited data set. As ensuing measurements are completed, we will have additional confidence in our results due to the increased number of field plots measured. As each measurement year is completed, the precision of estimates will improve.

Other significant changes between inventories include the implementation of new remote sensing technology, implementation of a new field plot design, and gathering of additional remotely sensed and field data. The advent of remote sensing technology since the previous inventory in 1998 allowed NCFIA to use computer-assisted classifications of Multi-Resolution Land Characterization (MRLC) data and other available remote sensing products to stratify the total area of the State and to improve estimates. Previous inventories used either manual interpretation of aerial photos to stratify the sample (1950, 1967, and 1986) or GAP satellite imagery (1998).

New algorithms were used in 1999 to assign forest type and stand-size class to each condition observed on a plot. These algorithms are being used nationwide by FIA to provide consistency among States and will be used to reassign the forest type and stand-size class of every plot measured in the 1998 inventory when it is updated. This will be done so that changes in forest type and stand-size class will more accurately reflect actual changes in the forest and not changes due to a change in how values are computed. The list of recognized forest types, grouping of these forest types for reporting purposes, equations used to assign stocking values to individual trees, definition of nonstocked (stands with a stocking value of less than 10 percent for all live trees), and names given to the forest types changed with the new algorithms.

PROCEDURES

The 1999 Indiana survey used a two-phase sample for stratification that included remeasuring inventory plots from the 1998 inventory and new field plots. Two-phase sampling, also called double sampling, consists of a phase-one sample used to estimate area by strata and a phase-two sample used to estimate the average value of parameters of interest within these strata. The estimated population total is the sum across all strata of each stratum's estimated area multiplied by its estimated mean per unit area.

The only land that could not be sampled was private land where field personnel could not obtain permission from the owner to measure a phase-two field plot. The methods used in the preparation of this report make the necessary adjustments to account for sites where access was denied. Fortunately, denied access plots were somewhat rare in Indiana. There were no denied access plots in the 1999 annual measurement and only 1 percent of the forested plots were denied access during the 1998 inventory.

Phase One

Phase-one and phase-two plots were placed systematically across the entire State and all lands have the same probability of being sampled under this inventory system. The 1999 inventory used a computer-assisted classification of satellite imagery for classification. FIA used the imagery to form two initial strata—forest and nonforest. Pixels within 60 m (2 pixel widths) of a forest/nonforest edge formed two additional strata—forest/nonforest and

nonforest/forest. Forest pixels within 60 m on the forest side of a forest-nonforest boundary were classified into forest/nonforest strata. Pixels within 60 m of the boundary on the nonforest side were classified into nonforest/forest strata. An overlay of all national forest land ownership was used to identify all lands owned by the Hoosier National Forest. These national forest lands were treated separately but were also stratified into one of the above four strata. Stratification and estimation were conducted at the State level for national forest lands and at the unit level for other lands. In the national forest stratum, forest and forest/nonforest strata were combined because there were fewer than five ground plots in one of these strata.

Phase Two

Phase two of the inventory consisted of the measurement of the first annual sample of field plots in Indiana. Current FIA precision standards for annual inventories require a sampling intensity of one plot for approximately every 6,000 acres. FIA has established a grid that divides the entire area of the United States into non-overlapping hexagons, each of which contains approximately 5,937 acres (McRoberts 1999). A grid of field plots was established by selecting one plot from each smaller hexagon based on the following rules: (1) if a Forest Health Monitoring (FHM) plot (Mangold 1998) fell within a hexagon, it was selected as the grid plot; (2) if no FHM plot fell within a hexagon, the existing NCFIA plot from the 1998 inventory nearest the hexagon center was selected as the grid plot; and (3) if neither FHM nor existing NCFIA plots fell within the hexagon, a new NCFIA plot established at the hexagon center was selected as the grid plot (McRoberts 1999). This grid of plots is designated the Federal base sample and is considered an equal probability sample; its measurement in Indiana is funded by the Federal government.

The total Federal base sample of hexagonal grid plots was systematically divided into five interpenetrating, non-overlapping subsamples or panels. Each year the plots in a single panel are measured, and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots may be considered an independent random sample of all land in a State. Field crews measured vegetation on plots that were forested at the time of the last inventory and on plots that were currently classified as forest by trained photo interpreters using aerial photos or digital ortho-quads.

NCFIA has two categories of field plot measurements—phase-three plots (FHM plots) and phase-two field plots to optimize our ability to collect data when available for measurement. Both types of plots are uniformly distributed both geographically and temporally. Phase-three plots are measured with the full array of FHM vegetative and health variables collected. Phase-three plots must be measured between June 1 and August 30 to accommodate measurement of non-woody understory vegetation, ground cover, soils, and other variables. We anticipate that in Indiana the complete 5-year annual inventory will involve about 60 phase-three plots. On the remaining plots, only variables that can be measured throughout the entire year are collected. In Indiana, the complete 5-year annual inventory is expected to involve about 860 phase-two forested plots.

The new national FIA 4-point cluster plot design (fig. 4) was first used for data collection during the 1998 inventory of Indiana. This design was also used in the 1999 inventory and will be used in subsequent years.

The national plot design requires mapping forest conditions on each plot. Due to the small sample size (20 percent) each year, precision associated with change factors such as mortality will be relatively low. Consequently, change estimates will not be reported until at least three annual inventories are completed, and even then we anticipate that

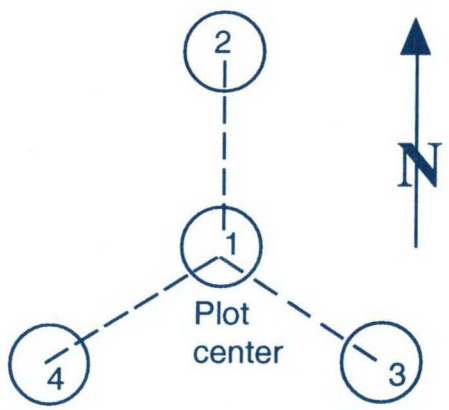

Figure 4.—*Current NCFIA field plot design.*

estimates of change will be limited in detail. When the complete annual inventory has been implemented in 2004, the full range of change variables will be available.

The overall plot layout for the new design consists of four subplots. The centers of subplots 2, 3, and 4 are located 120 feet from the center of subplot 1. The azimuths to subplots 2, 3, and 4 are 0, 120, and 240 degrees, respectively. The center of the new plot is located at the same point as the center of the previous plot if a previous plot existed within the sample unit. Trees 5 inches d.b.h. and larger are measured on a 24-foot-radius (1/24 acre) circular subplot. All trees less than 5 inches d.b.h. are measured on a 6.8-foot-radius (1/300 acre) circular microplot located at the center of each of the four subplots. Forest conditions that occur on any of the four subplots are recorded. Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on any of the subplots is identified, described, and mapped if the area of the condition meets or exceeds 1 acre in size.

Field plot measurements are combined with phase-one estimates in the compilation process and table production. The number of tables generated from a single year's data is limited, but as additional annual inventories are completed, the number of tables will increase until year 5, when all statewide inventory summary tables will be available in both printed and electronic formats. If additional information is desired, requests may be directed to:

Program Manager
Forest Inventory and Analysis
USDA Forest Service
North Central Research Station
1992 Folwell Ave.
St. Paul, MN 55108

or

State Forester
Indiana Department of Natural Resources
Division of Forestry
402 W. Washington St., Room W296
Indianapolis, IN 46204

LITERATURE CITED

Brundage, R.C. 1955. Forests of Indiana and their importance. West Lafayette, IN: Purdue University, Agricultural Extension Service cooperating with the Indiana State Department of Conservation.

Hansen, M.H.; Brand, G.J.; Wendt, D.G.; McRoberts, R.E. (In prep). Estimation based on the first cycle of the annual forest inventory system: methods, preliminary results and observation. Resour. Bull. NC-xxx. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. xx p.

Hutchison, O.K. 1956. Indiana's forest resources and industries. For. Resour. Rep. 10. Columbus, OH: U.S. Department of Agriculture, Forest Service, Central States Forest Experiment Station. 44 p.

Mangold, R.D. 1998. Forest health monitoring field methods guide (National 1998). Research Triangle Park, NC: U.S. Department of Agriculture, Forest Service, National Forest Health Monitoring Program. 429 p. (Revision 0, April 1998)

McRoberts, R.E. 1999. Joint annual forest inventory and monitoring system, the North Central perspective. Journal of Forestry. 97(12): 27-31.

Schmidt T.L.; Hansen, M.H.; Solomakos, J.A. 2000. Indiana's forests in 1998. Resour. Bull. NC-196. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 139 p.

U.S. GOVERNMENT PRINTING OFFICE: 2001-3600M 657-393 57393